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Abstract

This paper investigates piezoelectric micro-actuators with different electrode configurations, i.e., interdigital, spiral and radial electrodes. Using the finite element method, electromechanical performance is evaluated and a comparison of the different micro-actuators is made for equal field strengths. Then, the actuators are considered for tunable lenses and optical parameters are estimated using ray tracing. The interdigital-electrode configuration performs best in both electromechanical and optical analysis.

Keywords: piezoelectrics, actuators, interdigital electrodes, spiral electrodes, tunable lens.

1. Introduction

Piezoelectricity is suggested as a solution for a low power, fast switching and high-force micro-actuator among alternatives based on thermal, magnetic, and electrostatic driving principles [1]. Piezoelectric actuators have been employed in different micro systems such as micro-pumps, ultrasonic devices [2] and the tunable lens for autofocus cameras [3]. A common feature of these applications is the construction of a laminated diaphragm micro-actuator. The electromechanical coupling inside the piezoelectric layers depend on electrode configuration. Two conventional arrangements of electrodes that are commonly exploited are the top and bottom electrode (TBE) [4] with a transversal coupling governed by the piezoelectric constant d_{31} and the interdigital electrode (IDE) [5] with a longitudinal coupling governed by the piezoelectric constant d_{33}. A theoretical study [6] has confirmed that the IDE can be a better bender than the TBE for electric fieldstrength limited operation.

In this study, expanding on the two conventional electrode designs, a few electrode configurations for the piezoelectric micro-actuators are investigated. We focus on the effects of the different electrode configurations on the piezoelectric micro-actuators' bending. Because of the complexity of the electrode patterns, nonlinearities of the actuators may be complicated and possibly configuration dependent. Hence, for a relative comparison between different electrode configurations, we avoid this additional complexity by limiting our study to the linear actuation regime. Using the finite element method, a comparison of micro-actuators driven by different electrode arrangements, all with the same electric field strength, is made. Then, we configure the actuators as optical lenses. Using ray tracing analysis, performance figures of the lenses are estimated, i.e., F-number ($F\#$) and root-mean-square wavefront error (RMSWFE).

2. Device design and working principle

The patented tunable lens [3] is shown in Fig.1a. The lens consists of a polymer layer